DOCUMENT RESUME

ED 164 739 UD 019 070

AUTHOR Ross, Howard R.; Moon, Albert E.
TITLE Transportation Requirements for Improved Racial Balance. Research Memorandum No. 6.
INSTITUTION Stanford Research Inst., Menlo Park, Calif.
PUB DATE 15 May 67
NOTE 53p.; Parts may not reproduce well due to light print; For related documents, see UD 019 065-069 and UD 019 071

EDRS PRICE MF-$0.83 HC-$3.50 Plus Postage.
DESCRIPTORS *Bus Transportation; *Cost Effectiveness; Elementary Secondary Education; *Noninstructional Student Costs; Racially Balanced Schools; *School Integration; *Student Transportation
IDENTIFIERS *California (San Francisco)

ABSTRACT

This memorandum presents the costs of transporting students to achieve racial balance in the San Francisco public schools. The costs of a district owned school bus system are analyzed for a four year implementation period. Costs of different sizes and types of buses and of major operating requirements (including parking, buildings, staff, and maintenance) are estimated. Annual transportation costs per student are estimated. It is observed that the present contracted transportation arrangement provides a better use of equipment and, thus, is a financial benefit to taxpayers. New equipment would have to be procured at a greater cost to the city. (Author/WI)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

STANFORD RESEARCH INSTITUTE
MENLO PARK, CALIFORNIA

ED164739

STANFORD RESEARCH INSTITUTE
Menlo Park, California

May 15, 1967

Research Memorandum No. 6

TRANSPORTATION REQUIREMENTS FOR IMPROVED RACIAL BALANCE

Prepared for:

SAN FRANCISCO UNIFIED SCHOOL DISTRICT

By: HOWARD R. ROSS AND ALBERT E. MOON

Approved: WILLIAM J. PLATT, DIRECTOR
MANPOWER AND EDUCATION RESEARCH

U S DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Stanford Research Institute

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) AND USERS OF THE ERIC SYSTEM."

UDO 19070

Copy No. .....

FOREWORD

In September 1966, the San Francisco Unified School District contracted with Stanford Research Institute to study alternative techniques to improve racial balance in San Francisco's public schools. The following research memorandum is one of a series in which the Institute is presenting its findings.

The objectives of the overall study provide that the Institute develop and evaluate several alternative patterns of pupil attendance that, if adopted, would result in the racial makeup of individual schools more nearly matching the general racial distribution of the city. The cost and effectiveness of the various alternatives developed are evaluated in Research Memorandum No. 7.

This memorandum presents the costs of transporting students to achieve the requisite school attendance by race for the various alternatives. One alternative was selected (C-5 base case) for which origin and destination figures were generated to represent the required movement of students from school to school. The resulting flow figures were used to develop costs of district-owned and operated and contracted school bus systems. Cost factors were developed for extrapolation of the results to alternatives other than the C-5 base case.

Costs presented in this memorandum are preliminary in the sense that actual bids for equipment, buildings, land, and services would have to be obtained for an actual case before costs could be considered definitive. Such bids were not obtained, in part because the scope of work for this study was not extensive and in part because private organizations cannot make such bids unless the district selects a specific alternative plan and implementation schedule.

Howard R. Ross directed the preparation of this research memorandum. The analysis of costs was done by Albert E. Moon, and the determination of the number of buses by John L. Crain. The study was carried out under the administrative direction of Robert A. Harker, deputy project leader. William J. Platt, Director of Manpower and Education Research, was project leader.

CONTENTS

FOREWORD ii

SUMMARY 1

METHOD OF APPROACH 4

DETERMINATION OF NUMBER OF SCHOOL BUSES REQUIRED 6

Basis for Analysis 6
Assignment of Buses 6
Number of Buses and Route Miles Driven 13
Productivity Measures 17

COST ELEMENTS FOR DISTRICT-OWNED SCHOOL BUS OPERATIONS 19

Basic Costs 19
Alternatives 19
Costs of Buses 20
Land Costs 25
Buildings 26
Staff 28
Operating Costs 31

ANALYSIS OF COSTS 32

System Description 32
System Costs 35
Cost Summaries 39
Cost Comparisons 42
Cost Relationships and Extrapolations to Other Cases 43

ILLUSTRATIONS

1	School Bus Desire Lines: High School Level	10
2	School Bus Desire Lines: Junior High Level	11
3	School Bus Desire Lines: Elementary Level	12
4	79-Seat School Bus Utilization in 4th Year	18
5	Gillig 91-Passenger, 3-Axle, Transit-Type School Bus, 220 HP Diesel, Underfloor Mounting	21
6	67-Passenger, Conventional-Type School Bus, International Chassis	21
7	61-Passenger, Conventional-Type School Bus, Ford Chassis . .	22
8	Gillig 79-Passenger, Transit-Type School Bus, 220 HP Diesel, Underfloor Mounting	22
9	Gillig 79-Passenger, Transit-Type School Bus, 180 HP Diesel, Rear Mounting	23
10	Gillig 91-Passenger, Transit-Type School Bus, 220 HP Diesel, Underfloor Mounting, Three Axles, Dry Wall-Type Window . . .	23

TABLES

1	Transportation Requirements: 4th Year	7
2	Transportation Requirements: First 3 Years	8
3	General Transfer Requirements	9
4	Bus Schedules	14
5	Summary of Daily Bus Driver Time and Bus Distances for 4th Year	17
6	Costs of Gillig Transit-Type School Buses	24
7	Costs of 67-Passenger Conventional School Buses	25
8	Cost Summary: Fleet of 67-Seat Conventional School Buses	39
9	Cost Summary: Fleet of 79-Seat Transit School Buses	40
10	Cost Summary: Fleet of 91-Seat Transit School Buses	41
11	Statewide District-Owned and Contracted Bus Systems	44

SUMMARY

The costs of a district-owned school bus system for the San Francisco Unified School District were analyzed for the C-5 base case,* which would entail a four-year implementation period. Three standard sizes of school buses representing two basic types of bus were considered. The number of children to be transported in the fourth year would be 9,620; for this, the total number of school buses required and the total annual number of bus miles driven were determined to be:

Bus Size (Seats)	No. of Buses	Total Annual Bus Miles Driven
67	87	615,917
79	68	490,780
91	62	460,840

Costs of different sizes and types of school buses and major operating requirements for a district-owned school bus system were obtained--including parking area, buildings for administrative staff, and maintenance facilities. Relationships between fleet size and operating requirements were established. Sizes of staff and operating personnel were determined, and salaries and wages were estimated. Operating costs (fuel, oil, maintenance, parts, and insurance) were found to be:

Bus Size (Seats)	Cost per Bus Mile (Cents)
67	6.20¢
79	9.19
91	9.65

* The C-5 base case, which is analyzed in depth in this study, represents only one of the 12 alternatives. They are discussed in Research Memorandum No. 7.

These requirements were used to define a bus system for the fourth year of the C-5 base case. About 2.82 acres of land would be required to store sixty-two 91-seat buses and as the site for the staff and maintenance facility building, for which 8,800 square feet of floor area would be necessary. A staff of six plus five mechanics and 68 bus drivers would be required to operate sixty-two 91-seat buses in the fourth year.

The costs of operating the C-5 base case for the fourth year and on are summarized below:

	Bus Size (Seats)		
	67	79	91
Capital cost (thousands of dollars)	$1,562.6	$2,199.9	$2,236.7
Annual operating costs, 4th year and on	399.4	334.7	321.2

In the fourth year, using 91-seat buses, the annual cost per student transported was estimated to be $42.64. The annual cost per student for fleets using the smaller buses would be higher and is reported in the chapter on analysis of costs.

Cost estimates for a contracted operation were obtained from the San Francisco Municipal Railway. For the fourth year of operation, in which 9,620 students would be transported, this service would be provided at an annual cost to the district of $1,253,342, or $130.29 annually per student transported.* Western Greyhound Lines and M&M Charter Lines declined to quote a cost for providing this service.

Higher costs for the contracted service result from several factors. Buses used would hold only 48 students as opposed to 91 and would cost between $40,000 and $50,000 as compared with about $29,000 for the 91-seat transit school buses. Bus driver wages would be higher. Deadhead for the contracted service would be greater because buses would be drawn largely from the central business district. Municipal Railway officials who supplied these costs also noted that if the coaches were used with 3 children to a seat, then the cost of operation would be substantially reduced.

---

* The estimate provided by the Municipal Railway is reproduced in the appendix.

The Municipal Railway supplied these estimates on contracted costs to SRI for the C-5 base case. Officials of that organization offered the view that in assessing a district-owned versus a contracted system for moving students, the total net cost to the city, as opposed to simply the costs to the district, should be taken into account. They observed that the present arrangement provides a better use of equipment that has to be on hand anyway to serve the city, and that the result is of benefit to city taxpayers. Currently, funds are easily transferred from one department to another as compared with initiating a new district-owned school bus system where new equipment and facilities would have to be procured at possibly a greater net cost to the city.

Analysis of the total net cost to the city for either a contracted or district-owned system was not within the scope of this research.

METHOD OF APPROACH

The following methods were used to estimate the costs of transporting school children in the San Francisco Unified School District.

1. The C-5 base case, described in Research Memorandum No. 7, was used in the analysis. It represented, for transportation purposes, a matrix of flows between selected schools in the district in terms of number of children moved daily and time constraints.* This matrix was used to generate traffic desire lines, to which buses were assigned and scheduled in a logical, systematic manner. By this scheduling process, the number of buses and bus miles daily were developed for three standard sizes of school buses. These bus operation requirements were then generated in a similar manner for the four-year growth plan of the C-5 base case. Since different sizes of buses were considered, the fleet sizes would be different.

2. Costs of transit and conventional school buses were obtained from a major school bus manufacturer. Other major requirements that were determined included parking areas for buses, administrative staff, and maintenance facility buildings, as well as staff and operating personnel required. These requirements were determined by examination of actual district-owned and operated school bus systems of varying fleet sizes in several California school districts, and by establishing a relationship between fleet size and, for example, administrative staff and operating personnel requirements. Salaries and wages were obtained from the districts visited. Land costs were obtained by consultation with commercial real estate firms in San Francisco. Operating costs for school bus systems were obtained for two basic types of fleet: those based on conventional school buses and those on transit school buses. They were secured from two large district-owned systems, one composed almost entirely of conventional buses and the other of transit-type buses. All costs were treated parametrically, with fleet size the principal

---

* In the C-5 pattern, which is organized on a 3-3-3-3 grade level, Polytechnic High School is closed and students are bused to Benjamin Franklin Academic Senior High School.

variable. This approach presents costs in a way that requirements and costs could be derived for any size of bus fleet.

3. The requisite facilities, personnel, and equipment were described for a set of different bus sizes. A cost schedule was prepared from this description to show capital and operating costs for the first four years of the C-5 base case. A comparison of costs of systems based on different types and sizes of school buses was made. Cost data on district-owned and contracted school bus systems were assembled and compared with the hypothetical San Francisco district-owned system. Cost factors were developed for extrapolation of these results to other alternatives that might be selected.

4. From the same basic flow patterns used for the C-5 base case analysis in this study, the San Francisco Municipal Railway estimated their charges for providing this service. As SRI was not involved in making these estimates, they are simply reported in the summary.

DETERMINATION OF NUMBER OF SCHOOL BUSES REQUIRED

Basis for Analysis

The bus operations required were established for the C-5 base case by analyzing the flow patterns representing the required movements of children from school to school. This flow pattern is presented in Tables 1 and 2, which show origin and destination schools, number of students to be transported, and school starting and closing times. The C-5 base case calls for the number of school children transported to be increased from the first year until the fourth year, in which a total of 9,620 children would be transported daily. Thus, if the C-5 plan were to be implemented in 1968, 9,620 children would be transported in the 1971-72 school year.

Assignment of Buses

The next step of the analysis consisted in assigning buses to the flow patterns. This scheduling operation was necessary to determine the size of the bus fleet required--the major factor in capital costs--and to determine the number of bus miles that the fleet would travel annually--the major determinant of operating costs.

To assign buses to flow patterns, the fourth year transportation requirements (Tables 1 and 2) were translated into desire line diagrams, as shown in Figures 1, 2, and 3. These diagrams, superimposed on a map of the city, show graphically the number of students to be transported from origin schools to destination schools. A desire line map is shown for high school, junior high school, and elementary school children. Flows are shown separately because they occur at different times. They are divided into eight basic movements, designated by Roman numerals, and described in Table 3.

Table 1

TRANSPORTATION REQUIREMENTS
4th Year

To	From Pickup Point: Fair-mount	Pelton	Hunters Point	Andrew Jackson	Raphael Weill	Commodore Stockton	Mission District	John Swett
High Schools (8:15 a.m.-3:10 p.m.)								
Lowell		110	230					
Abraham Lincoln			415					
Balboa	340							
George Washington				320				
Diamond Heights*					400	755		
Galileo							245	
Junior High Schools (8:30 a.m.-3 p.m.)								
Luther Burbank	440							
A. P. Giannini			535					
Aptos			300					
Presidio				285				
Herbert Hoover					500			
James Lick						465		
Marina							360	
Francisco								130
Elementary (4-6 grades) 8:50 a.m.-3:10 p.m.								
Mark Twain			305					
Francis Scott Key			250					
Ulloa			200					
Phoebe A. Hearst			110					
Alamo				300				
Winfield Scott							105	
Grant							275	
8:50 a.m.-2:30 p.m.								
Noriega			105					
Robert L. Stevenson			200					
Lawton			250					
Parkside			200					
New Ulloa*			110					
Yerba Buena							105	
Emerson							275	

Total = 9,620

* New school.

Table 2

TRANSPORTATION REQUIREMENTS
First 3 Years

To	From Pickup Point														
	Year 1			Year 2				Year 3							
	Hunters Point	Mira-loma	Fair-mount	Hunters Point	Andrew Jackson	Mira-loma	Fair-mount	John Swett	District Mission	Commodore Stockton	Raphael Weill	Andrew Jackson	Hunters Point	Mira-loma	Fair-mount
High Schools (8:15 a.m.-3:10 p.m.)															
Balboa			230				340								340
Mission		350				500								150	
Polytechnic										510				350	
Galileo									100						
George Washington					210							320			
Junior High Schools (8:30 a.m.-3 p.m.)															
Luther Burbank			300				440								440
A. P. Giannini													350		
Aptos													200		
Presidio					190							285			
Herbert Hoover											500				
James Lick										315					
Marina									240						
Francisco								130							
Elementary (4-6 grades) 8:50 a.m.-3:10 p.m.															
Mark Twain													200		
Francis Scott Key													170		
Ulloa													140		
Phoebe A. Hearst													70		
Alamo					200							300			
Winfield Scott									70						
Grant									180						
8:50 a.m.-2:30 p.m.															
Noriega	70			105									105		
Robert L. Stevenson	130			200									200		
Lawton	170			250									250		
Parkside													140		
New Ulloa*													70		
Yerba Buena									70						
Emerson									180						
Total		1,250			2,435						6,375				

* New school.

Table 3

GENERAL TRANSFER REQUIREMENTS

Traffic Flow Line*	Geography Entailed	Schools Entailed
I	Golden Gate area	Jackson to George Washington Jackson to Presidio Jackson to Alamo
II	Hunters Point to Sunset Boulevard area	Hunters Point to Abraham Lincoln Hunters Point to Lowell Pelton to Lowell Hunters Point to Mark Twain Hunters Point to R. L. Stevenson
	Hunters Point to Giannini Hunters Point to Aptos	Hunters Point to Noriega Hunters Point to F. S. Key Hunters Point to Lawton Hunters Point to P. A. Hearst Hunters Point to New Ulloa Hunters Point to Ulloa Hunters Point to Parkside
III	North Beach to Diamond Heights	Commodore Stockton to Diamond Heights Raphael Weill to Diamond Heights
IV	Mission District to Fisherman's Wharf area	Mission District to Galileo Mission District to Marina John Swett to Francisco
V	Mission District to Marina area	Mission District to Winfield Scott Mission District to Yerba Buena Mission District to Grant Mission District to Emerson
VI		Raphael Weill to Herbert Hoover
VII		Commodore Stockton to James Lick
VIII		Fairmount to Balboa Fairmount to Burbank

* See Figures 1, 2, and 3.

Figure 1

SCHOOL BUS DESIRE LINES
High School Level

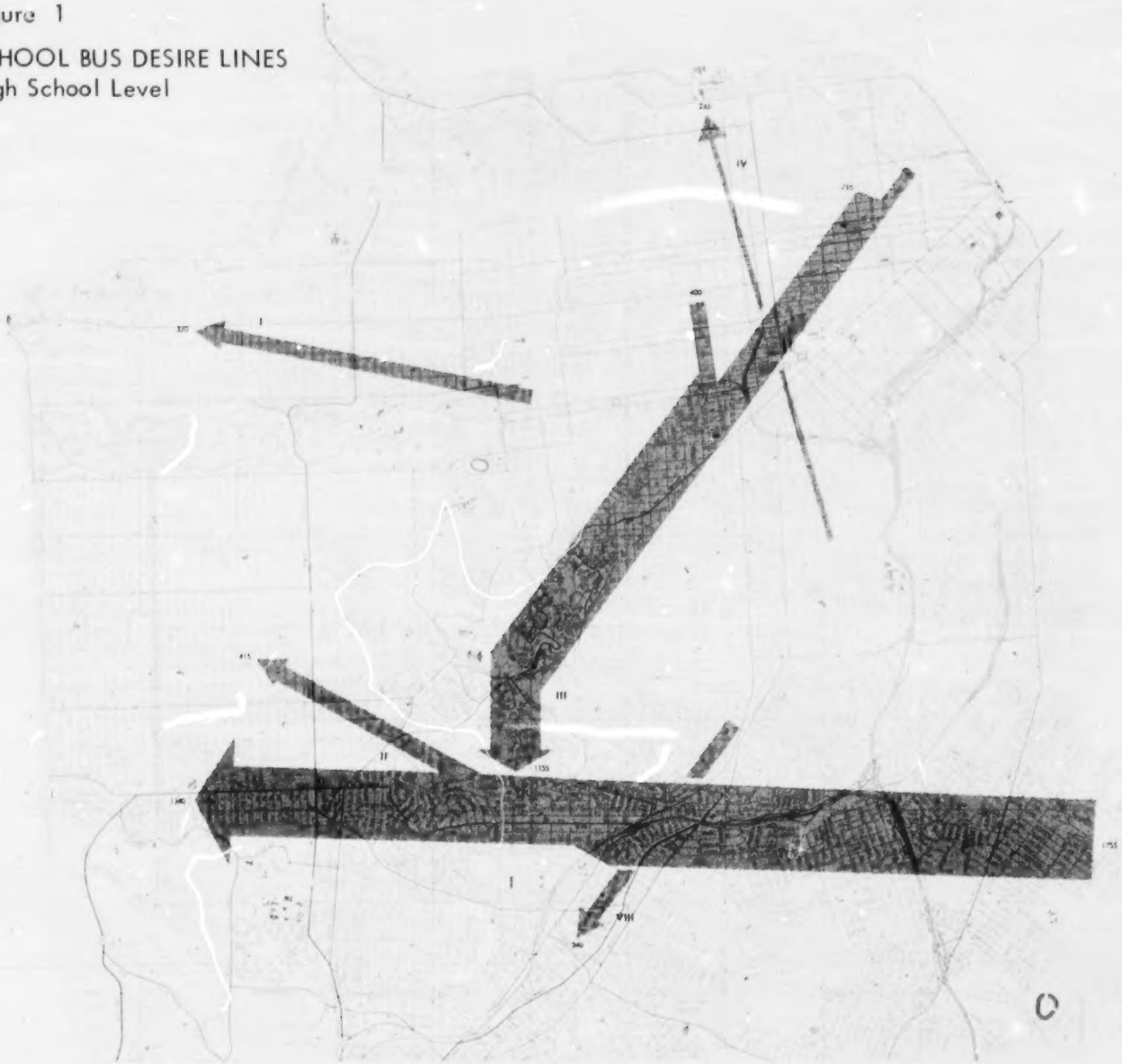


Figure 2

SCHOOL BUS DESIRE LINES
Junior High Level

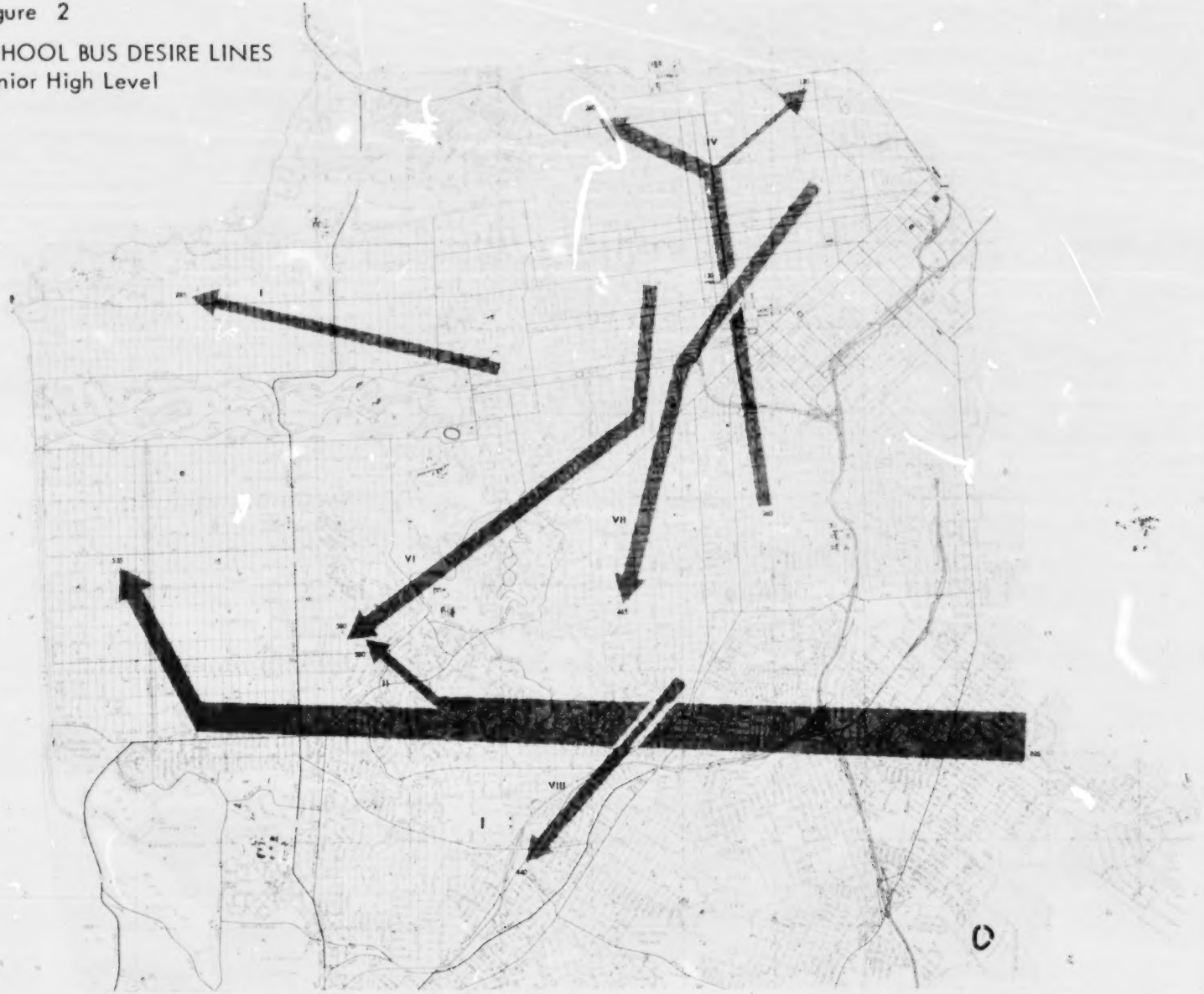
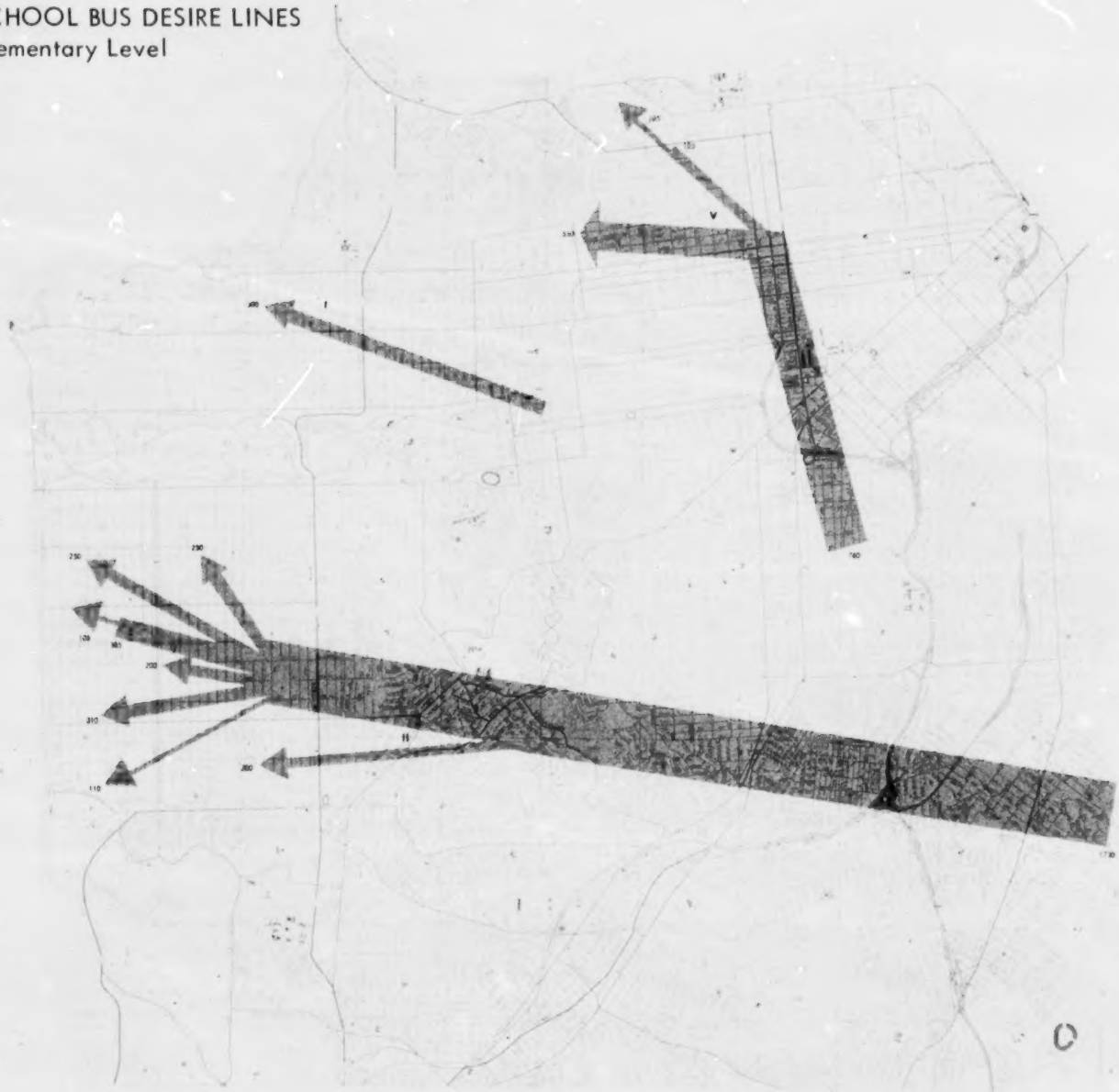


Figure 3

SCHOOL BUS DESIRE LINES
Elementary Level



Scheduling of buses and fixing the number of buses required were subject to the following constraints:

1. School hours, as shown in Tables 1 and 2, and repeated below:

Level	Hours
High school	8:15 a.m. - 3:10 p.m.
Junior high	8:30 a.m. - 3:10 p.m.
Grades 4-6	8:50 a.m. - 3:10 p.m.
Grades 1-3	8:50 a.m. - 2:30 p.m.

2. No student may be delivered more than 30 minutes before the start of school.

3. There must be a seat available for every child on the bus.

4. Three bus sizes were used: 67, 79, or 91 seats.*

Transit times were estimated by using average speeds of trial trips by automobile over some of the routes with appropriate adjustments made to reflect bus operations. These transit times, considered in conjunction with requisite flows and constrained by the times listed above, were used to develop a logical and efficient assignment of buses and schedule therefor. It was determined that seven different groups of buses would be needed to service the eight movements shown in Figures 1, 2, and 3. These bus groups are designated in Table 4 as A, B, C_1, C_2, and so forth. Also shown are transit times for morning and afternoon schedules.

Number of Buses and Route Miles Driven

The simulated scheduling of buses was carried out to determine closely how many buses would be required, how many route miles would be incurred by each bus annually, and how many students would be delivered by each bus. Three different sizes of buses were considered: 67-, 79-, and 91-seat buses. The number of buses needed to transport all students

---

* The 67-passenger bus is the largest conventional school bus; the 79- and 91-passenger buses are standard transit-type school buses. These equipment characteristics are discussed in the chapter on cost elements.

Table 4

BUS SCHEDULES

Bus Group*	Morning Schedule		Afternoon Schedule	
	Movements	Schedule	Movements	Schedule
A	I (HS)	7:40 to 7:55	I (JHS)	3:00 to 3:15
	I (JHS)	8:05 to 8:20	I (ELEM)	3:25 to 3:40
	I (ELEM)	8:30 to 8:45	I (HS)	3:50 to 4:04
B	II (HS)	7:30 to 7:55	II (ELEM)	2:30 to 2:55
	II (ELEM)	8:20 to 8:45	II (HS)	3:20 to 3:45
			II (ELEM) (4-6)	3:10 to 3:35
			II (HS)	4:00 to 4:10
C_1	III (HS)	7:20 to 7:45	II (JHS)	3:00 to 3:25
	II (JHS)	8:05 to 8:30	III (HS)	3:45 to 4:10
C_2	IV (HS)	7:20 to 7:45	IV (JHS)	3:00 to 3:20
	IV (JHS)	8:05 to 8:30	IV (HS)	3:40 to 4:00
C_3	III (HS)	7:20 to 7:45	IV (JHS)	3:00 to 3:20
	IV (JHS)	8:05 to 8:30	IV (HS)	3:40 to 4:00
D_1	VI (JHS)	7:40 to 8:05	V (ELEM)	2:30 to 2:55
	VII (JHS)	7:35 to 8:00	VII (JHS)	3:15 to 3:40
	V (ELEM)	8:25 to 8:50	V (ELEM) (4-6)	3:19 to 3:35
			VI (JHS)	3:55 to 4:20
D_2	VIII (HS)	7:40 to 7:55	VIII (JHS)	3:00 to 3:15
	VIII (JHS)	8:10 to 8:25	VIII (HS)	3:30 to 3:45

* Productivity of bus groups is shown in Figure 4.

was computed for each bus size. Buses and route miles are presented in the tabulation below for the fourth year.

Bus Size (Seats)	Buses Needed	Spares	Total Buses
67	82	5	87
79	65	3	68
91	60	2	62

This process was then repeated for the intervening years, resulting in the following:

Bus Size (Seats)	Buses Needed	Spares	Total Buses	Total Annual Miles Driven
		First Year		
67	12	1	13	78,070
79	9	1	10	39,836
91	8	1	9	38,412
		Second Year		
67	21	1	22	143,432
79	17	1	18	104,824
91	15	1	16	104,735
		Third Year		
67	53	3	56	414,704
79	44	2	46	347,527
91	43	1	44	337,132

Spare buses indicated above are necessary in the event a regular bus is disabled. Spare requirements were determined by discussions with operating groups from other school districts. The 67-seat vehicles are conventional school buses, for which about 6 percent spares were allowed; the 79- and 91-seat vehicles are transit school buses for which about 4 percent spares were allowed. The differences between these two basic types of school buses are discussed in the chapter on cost elements.

To transit times must be added the deadhead times, not only from the origin school to the terminal, but also those incurred when a bus returns empty for a second load of children; the same scheduling process as before was used to develop these times. In Table 5, the total times are presented for the three different types of buses considered for Year 4.

It was assumed that each driver would leave his bus at the final school on the day's route; one bus from each area would collect all drivers from all schools in that area and deliver them to the terminal. This arrangement results in a small increase in driver time but reduces bus miles by a significant factor.

The process of determining number of buses, number of spares, and total miles driven was repeated for the first three years. The following summarizes this information by year:

Bus Size (Seats)	Buses Needed	Spares	Total Buses	Total Annual Miles Driven
		First Year		
67	12	1	13	78,070
79	9	1	10	39,836
91	8	1	9	38,412
		Second Year		
67	21	1	22	143,432
79	17	1	18	104,824
91	15	1	16	104,735
		Third Year		
67	53	3	56	414,704
79	44	2	46	347,527
91	43	1	44	337,132
		Fourth and Succeeding Years		
67	82	5	87	615,917
79	65	3	68	490,780
91	60	2	62	460,840

Table 5

SUMMARY OF DAILY BUS DRIVER TIME
AND BUS DISTANCES FOR 4TH YEAR

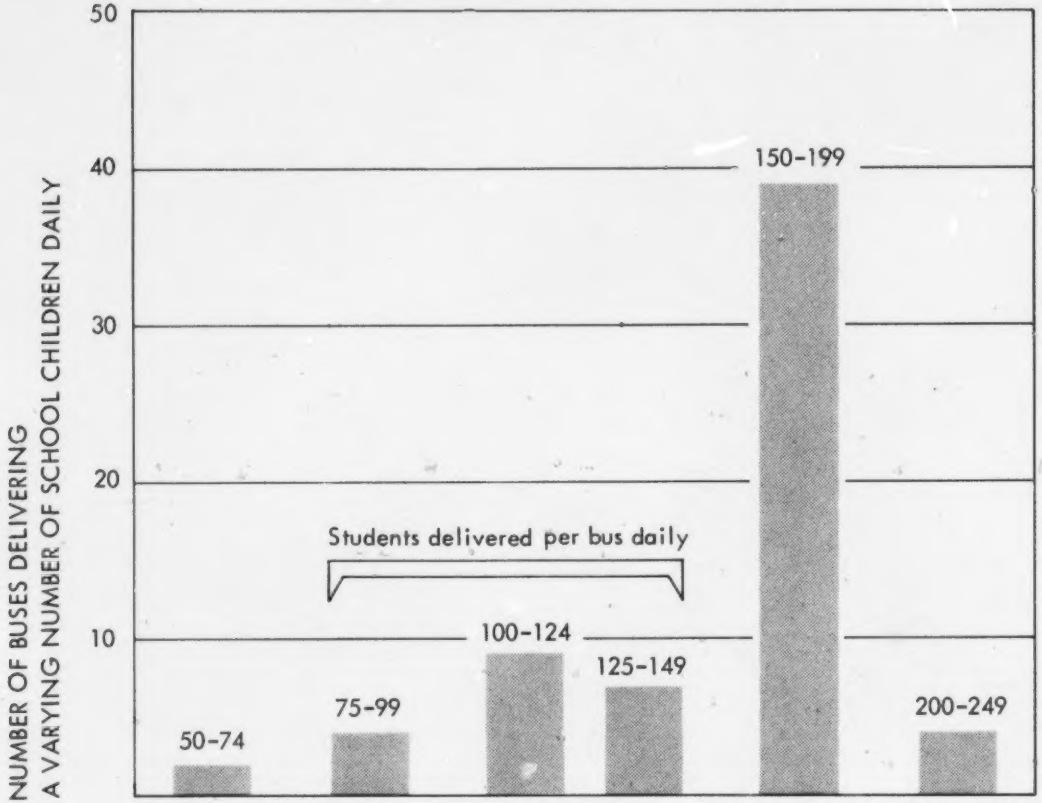
	Bus Size (seats)		
	67	79	91
Use of buses, total			
Distance (miles)	2,023	1,584	1,465
Time (minutes)	7,510	6,040	5,660
Deadhead distance (miles)			
Between schools	892	713	670
To and from terminals	545	460	444
Deadhead time (minutes)			
Between schools	3,320	2,706	2,562
To and from terminals	6,220	4,956	4,606
Warm-up time (minutes)	1,230	975	900
Total daily			
Distance (miles)	3,460	2,757	2,579
Time (minutes)	18,280	14,677	13,728

Productivity Measures

The scheduling technique resulted in buses being used at various levels of productivity, as illustrated in Figure 4, which shows that most of the buses in the fleet carry between 150 and 199 school children per day, or about two bus loads. A few carry more, some less, and two buses would carry less than 74 (i.e., less than a full 79-seat bus load) per day. These measures of productivity are on the basis of 79-seat buses.

Figure 4

79-SEAT SCHOOL BUS UTILIZATION IN 4TH YEAR



COST ELEMENTS FOR DISTRICT-OWNED SCHOOL BUS OPERATIONS

Basic Costs

Two basic costs are involved in these systems: capital costs and operating costs. Capital costs include buses, parking areas, and administrative and maintenance facilities. Operating costs include administrative staff salaries, wages for maintenance and operating crew, insurance, and fuel, parts, oil, and grease for buses. Since these costs are basically related to the size of the bus fleet, it was decided that costs would be developed for a range of bus fleet sizes, in this case from 25 to 100 buses taken in 25-bus steps.

Alternatives

Basic alternatives are available for these costs. For example, a bus fleet may be composed of conventional school buses with lower initial costs but higher operating costs, or it may be composed of mostly transit-type school buses with higher initial costs but lower operating costs. It is important to distinguish between transit and conventional school buses. The transit bus is built to carry up to 73, 79, or 91 pupils, whereas the conventional bus is smaller, ranging from a top of about 67 pupils down to 40 or less. The transit bus is built with a specially designed bus chassis, and the overall construction is heavier and of higher quality; the conventional bus is built on a truck chassis with substantially lighter materials throughout. From observations in the Gillig plant,* the workmanship that goes into transit buses is of higher quality than that for conventional buses almost across the board, which discussions with the school districts bore out.

These differences in construction quality are reflected in the costs, with 79-seat transit buses averaging about $25,000 each and conventional 67-seat buses averaging about $9,000 to $11,000 each, depending on manufacturing options. The transit buses have greater power and maneuverability than do conventional buses and require greater driving skill. The transit buses are considered safer for handling children because of improved forward visibility, greater weight and impact strength, and

---

* Gillig Brothers Coach & Bus Company, 50 El Dorado Street, Hayward, California.

because the front wheel is back of the loading door. Greater comfort, lower maintenance, and longer operating life are also obtained from the transit buses. Power steering is standard on the transit buses and optional on the conventional buses. Figures 5 through 10 illustrate these two types of buses, with minor variations within each type.

One size of conventional school bus was examined and two sizes of transit school buses. These were 67-, 79-, and 91-seat buses, respectively.

Costs of Buses

The costs of the 79- and 91-seat Gillig transit-type buses are given in Table 6. Although smaller transit-type buses can be manufactured, reducing the size of the bus to 73 or 67 seats does not produce proportionate cost reductions. The reduction achieved for the smaller buses would be $200 to $400. One should note that the cost of the 91-seat bus is roughly the same as the 79-seat bus on a cost-per-seat basis. However, the larger buses are favored because of reduced driver costs on a capacity basis, provided that the buses can be filled and scheduled efficiently.

These transit school buses are also manufactured by Crown Bus Company in Los Angeles, the single major competitior of Gillig. The cost figures Gillig supplied for this type of bus are competitive with those that Crown would supply, and, therefore, these figures were used in the cost analyses.

Costs for only one size of conventional school bus were obtained--an 11-row or 67-passenger bus. These costs are presented in Table 7.

These cost data were used to arrive at a cost of three sizes of bus as follows:*

Type	Seats	Cost
Conventional	67	$12,100
Transit	79	25,000
Transit	91	28,700

These unit costs were used in the chapter on cost analysis.

---

* Both sets of costs were supplied by Gillig Brothers. Actual costs at time of purchase may vary considerably from these figures depending on market conditions.

Figure 5

GILLIG 91-PASSENGER, 3-AXLE, TRANSIT-TYPE SCHOOL BUS,
220 HP DIESEL, UNDERFLOOR MOUNTING

Figure 6

67-PASSENGER, CONVENTIONAL-TYPE SCHOOL BUS,
INTERNATIONAL CHASSIS

Photo courtesy of Gillig Brothers.

Figure 7

61-PASSENGER, CONVENTIONAL-TYPE SCHOOL BUS,
FORD CHASSIS

Figure 8

GILLIG 79-PASSENGER, TRANSIT-TYPE SCHOOL BUS,
220 HP DIESEL, UNDERFLOOR MOUNTING

Photo courtesy of Gillig Brothers.

Figure 9

GILLIG 79-PASSENGER, TRANSIT-TYPE SCHOOL BUS,
180 HP DIESEL, REAR MOUNTING

Figure 10

GILLIG 91-PASSENGER, TRANSIT-TYPE SCHOOL BUS, 220 HP DIESEL,
UNDERFLOOR MOUNTING, THREE AXLES, DRY WALL-TYPE WINDOW

Photo courtesy of Gillig Brothers.

Table 6

COSTS OF GILLIG TRANSIT-TYPE SCHOOL BUSES

Identification	C-180	743D-13	743D-15
Passengers	79	79	91
Number of rows	13	13	15
Type of power plant	Cummins diesel	Cummins diesel	Cummins diesel
HP	180	220	220
Location of power plant	Rear	Underfloor	Underfloor
Number of axles	2	2	2
Basic cost	$20,420	$22,620	$25,650
MGM automatic safety brake*			
Williams compression brake*			
Stainless panels, and so forth*			
Wagner spitter valve for air system*			
Air horn*			
Caged fan*			
6312 U/S heater*			
Rubber floor covering*			
Safety cross mirror*			
5662 6-speed transmission*			
Water filter*			
Extra tread tires*			
Total cost	$22,137	$24,310	$27,600

* Cost data on these items were supplied to SRI by Gillig in confidence.

Table 7

COSTS OF 67-PASSENGER CONVENTIONAL SCHOOL BUSES*

	Gillig Body†	Superior Body‡
Basic cost	$11,000	$ 9,500
Allison automatic transmission	1,000	1,000
Air brakes	500	500
Two-speed axle	350	350
Aluminum body	300	300
Total	$13,950	$11,650

* Wheelbase 253 inches to 261-1/2 incnes; V8-345 to 361 cu in. displacement; 5-speed synchromesh transmission; 7,000-lb front and 16,000-lb rear axle, power steering, engine tachometer, 11 rows of seats.

† Gillig body higher in cost because of the following features: 18-gauge side panels versus 20-gauge for Eastern bodies; 5-ply plywood floors in lieu of 14-gauge sheet metal; double cowl instead of single cowl; 75-1/2 inches headroom versus 72 inches headroom; custom built versus assembly line production.

‡ Superior is an Eastern manufacturer of conventional school buses for whom Gillig is the Western outlet.

Land Costs

The major land required for district-owned systems is for parking, although a small amount is also necessary for the maintenance and administrative staff building site. On the basis of the experience of the various districts with whom this was discussed, the parking area as a function of number of vehicles is about 25 buses on an acre of land.*

* A parking lot of a given size will usually accommodate about an equal number of smaller vehicles such as station wagons, which occupy space unusable for the buses.

Thus a 100-bus fleet would require about 4 acres; or about 1,600 square feet per bus, independent of bus size. Ten thousand square feet of land were allowed for the site of the administrative staff building and 13,500 to 15,000 square feet of land for the maintenance facilities (see building costs below).

Estimates of land costs in San Francisco must be regarded as highly uncertain. Two general areas were selected that bore a good relationship to the major traffic origin point. These areas were in Hunters Point, where generally more vacant land is available than in any other part of the city, and an area bounded roughly by Army Street on the south, Highway 101 on the west, and 16th Street on the north (designated Potrero Park Area). A commercial real estate firm in the city supplied costs of land as follows:*

Hunters Point: $86,000/acre
Potrero Park Area: $129,000/acre

For the analysis of deadhead times and distances, the Hunters Point area was selected for a single parking lot for the bus fleet. It was assumed that a land parcel of the requisite size could be obtained. A figure of $100,000/acre was assigned to the Hunters Point area, and it was used in the cost analyses. Actual land requirements and costs for the C-5 base case are in the chapter on cost analysis.

Buildings

Facilities for maintenance, repair, and parts storage require the largest building area. For each 20 pieces of equipment--buses, trucks, or station wagons--one maintenance stall should be provided, with at least one stall equipped with hoist; for larger fleets there should be one hoist in every three stalls. A paint room is recommended for any fleet above 50 buses. A tire shop and machine shop together occupying the space of one complete stall are recommended for any system over 25 buses. Enclosed storage space for parts of 25 square feet for each bus is a good general rule. These factors were established by discussions with several district-owned system transportation departments.

---

* These figures were supplied by William H. Banker, Coldwell-Banker, Inc., 5057 Sutter Street, San Francisco, California.

These factors were considered in sizing the maintenance, repair, and parts storage facilities for bus fleets of various sizes as follows:

25-Bus Fleet

2 stalls, one with hoist, 15 feet x 50 feet each
1 stall for tire shop and machine shop, 15 feet x 50 feet
Storage space of 625 sq ft

Total: 2,875 sq ft

50-Bus Fleet

3 stalls, one with hoist, 15 feet x 50 feet each
1 stall for tire shop and machine shop, 15 feet x 50 feet
Storage space of 1,250 sq ft
Paint shop 20 feet x 50 feet

Total: 5,250 sq ft

75-Bus Fleet

4 stalls, one with hoist, 15 feet x 50 feet each
1 stall for tire shop and machine shop, 15 feet x 15 feet
Storage space of 1,875 sq ft
Paint shop, 20 feet x 50 feet

Total: 6,625 sq ft

100-Bus Fleet

5 stalls, two with hoists, 15 feet x 50 feet each
1 stall for tire shop and machine shop, 15 feet x 50 feet
Storage space of 2,500 sq ft
Paint shop 20 feet x 50 feet

Total: 8,000 sq ft

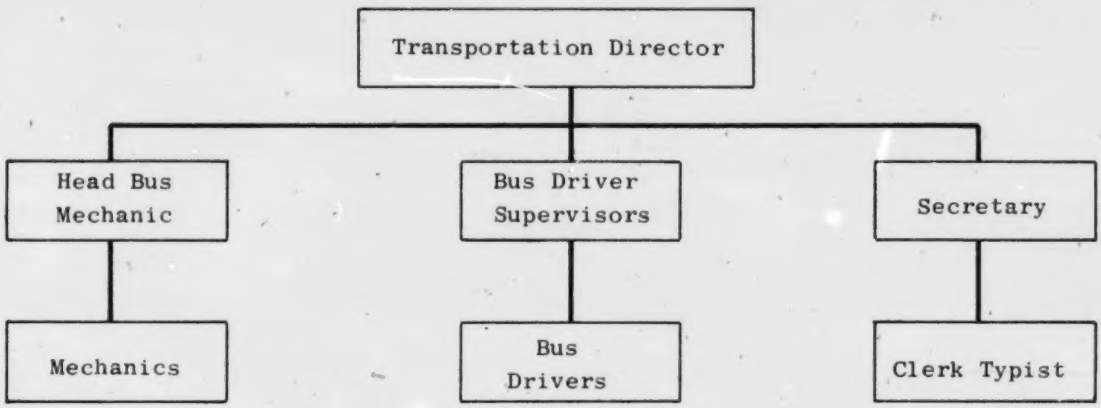
Additional costs for these facilities include about $12,000 to $15,000 for other equipment (e.g., wheel balancing, lathes, hoists, spray booth equipment) including a 5,000-gallon gasoline and a 10,000-gallon oil tank; for a fleet of all one type a single 15,000-gallon tank is recommended.

Building costs were estimated on the basis of $13/square foot for the type of garage construction envisioned, and $20/square foot for the office building.

These factors were used to size the buildings for the various bus fleet sizes under consideration; a summary of total building costs for the C-5 base case is presented in the chapter on cost analysis under System Description.

Staff

A typical transportation department for a district-owned system is diagrammed below:



Every system will have a transportation director. The head bus mechanic is required for systems of 50 buses or more. The number of mechanics is, roughly, slightly less than one for each 10 pieces of equipment. In the larger systems distinctions are made between mechanics and senior mechanics. Driver supervisors* are required at a rate of about one for each 25 bus group, slightly less in the larger systems. Bus drivers must be provided for each bus, plus about 10 percent substitute drivers. The secretary and clerk-typist are both provided in the larger systems; in the small operations the secretary takes over the clerk-typist role. These rules are not to be interpreted too rigidly, and in actual practice judgment is used to match staff and operating crews to the bus fleet.

---

* Called field coordinators or foremen in some systems.

The major staff and operating crews required for a range of bus fleet sizes of interest are presented below:

25-Bus Fleet

- Transportation director
- Bus driver supervisor
- 2 Mechanics
- Secretary
- 28 Bus drivers

75-Bus Fleet

- Transportation director
- 2 Bus driver supervisors*
- Head mechanic (working)
- 5 Mechanics
- 80 Bus drivers
- Secretary
- Clerk-typist

50-Bus Fleet

- Transportation director
- 2 Bus driver supervisors*
- Head mechanic (working)
- 3 Mechanics
- 55 Bus drivers
- Secretary

100-Bus Fleet

- Transportation director
- 3 Bus driver supervisors*
- Head mechanic
- 7 Mechanics
- 110 Bus drivers
- Secretary
- Clerk-typist

The actual staff requirements for the 4-year period are shown as a function of bus fleet sizes in the next chapter.

Salaries and wages of staff and operating crew were determined by examining rates for various districts in California. The transportation director's salary varies from $10,000 to $12,000 annually in the Mt. Diablo district; $12,000 to $15,500 in the San Juan district; and might go as high as $18,000 annually for a 100-bus system, depending somewhat on location.

---

* Would be increased by one for split parking-maintenance facilities, i.e., as opposed to a central facility, to which these requirements apply.

Figures for the San Juan district were given as:

	Annual Pay	
	Low	High
Bus driver supervisor	$6,850	$8,340
Head bus mechanic	7,370	8,830
Bus mechanic	6,360	7,740
Bus drivers	$2.52/hr	$3.06/hr
Clerk-typist	5,364	6,258

It is recognized that the costs of labor for bus drivers and mechanics would probably be higher for San Francisco than, for example, the Mt. Diablo or the San Juan district; therefore, these costs were also obtained from the Los Angeles district:

	Hourly Pay		
	Low	Mid	High
Bus drivers	$3.1375	$3.52	$3.89375
Head bus mechanic	3.7875	4.2250	4.7125
Senior bus mechanic	3.40	3.89375	4.225
Bus mechanic	3.21875	3.5875	4.000

Bus drivers in Los Angeles are paid for a minimum of 4 hours' work and are civil service employees.

In the six districts visited, women bus drivers predominate to the extent of 80 or 90 percent of the total. Some uncertainty exists as to whether a district-owned bus system for San Francisco would use union or nonunion drivers; furthermore, it could not be known in advance whether a union contract could be negotiated for less than an 8-hour day. Practice for the districts visited is for drivers (nonunion) to have a temporary employment status and be paid for actual hours worked.

The M&M Charter Lines, which currently uses small school buses to provide transportation for handicapped children in the SFUSD, uses union drivers (Brotherhood of Railroad Trainmen). Their contract calls for a

minimum of 3 hours' work. Pay scales average about $2.93/hour for women drivers (nonlift) and $3.90/hour for men drivers (handling lift-cases).*

The analyses used the Los Angeles bus driver midpay scale, or $3.52 per hour plus 15 percent for fringe benefits. This figure seemed consistent with the M&M union pay scale and, as it applied to a large metropolitan area, seemed appropriate to San Francisco.

Operating Costs

We were concerned with two basic types of bus fleets: one using conventional school buses and one using transit school buses. The Mt. Diablo Unified School District Transportation Department in Concord operates a 77-bus fleet of conventional school buses. The San Juan Unified School District operates an 85-bus fleet of transit school buses. Operating costs were secured from both districts, and include fuel, oil, grease, parts, and maintenance labor.

For the 67-seat conventional school buses, aggregate operating costs of 6.20¢ per bus mile were obtained. For the 79-seat transit buses, the figure of 9.19¢ per bus mile was obtained by analysis of recorded operating costs since 1963 from the San Juan district. Operating costs of the 91-seat buses were obtained by assuming that their operating costs, of which about half is for fuel, would average about 5 percent more than the 79-seat buses, resulting in 9.65¢ per bus mile.

---

* Information supplied by Elmo Ramsey, M&M Charter Lines, 1945 Evans Avenue, San Francisco, California.

ANALYSIS OF COSTS

This chapter combines the number of buses previously determined with the cost elements for district-owned school bus systems. The result is a system description of the required facilities, personnel, and equipment for a set of alternative bus sizes. From the system description a cost schedule is developed to show capital and operating expenditures for the first four years. The costs of the three bus size alternatives are compared. Finally, ratios and projections are presented that can be used to compare the performance of the hypothetical San Francisco district-owned school bus system with other district-owned systems in the state.

System Description

For a district-owned school bus system that would meet the transportation requirements of the C-5 base case, three different bus sizes were considered: 67-, 79-, and 91-seat buses. Each alternative bus size considered requires differing amounts of capital equipment, personnel, and operating supplies. The following description presents the elements of the bus system that have been taken into account in the cost analysis and shows their pattern of growth over the first four years of operation.

Buses

Considering the number of buses required plus spares, as presented in Table 4, the acquisition schedule would be as follows:

Bus Size (Seats)	Year 0	1	2	3
67	13	9	34	31
79	10	8	28	22
91	9	7	28	18

This tabulation shows purchases at the end of the year preceding the year in which they will be required. For example, the 13 buses with a

seating capacity of 67 students that would be required in Year 1 are purchased at the end of Year 0.

Land Requirements

Land requirements were derived from the number of buses, as described in the chapter on cost elements. For cost analysis, it was assumed that a site having the requisite area could be obtained in the Hunters Point area. The costs again occur in Year 0 to have the facility ready for the first year's operation. The land requirements are shown in the following tabulation:

	Bus Size (Seats)		
	67	79	91
Number of buses in fleet	87	68	62
Land for staff building (sq ft)	10,000	10,000	10,000
Land for bus parking	139,200	108,800	99,200
Land for maintenance facility	15,000	14,500	13,500
Total area	164,200	133,300	122,700
Acres	3.77	3.06	2.82

Buildings and Equipment

A building to house the administrative staff, a driver's check-in room and locker room, maintenance and repair facilities, and office equipment have been included in the cost estimate. We assumed that full facilities for the fourth year would be acquired in the first year. Requirements established in the cost elements chapter indicate that office building space for driver's check-in and locker room of 2,500 square feet would be necessary for operation of the fourth-year fleet. Cost of office equipment is estimated at $2,000. The size of the maintenance and repair facilities is governed by the number of buses in the fleet, in turn a function of the size of bus selected. For the fourth year C-5 base case, the building floor space requirements are:

	Bus Size (Seats)		
	67	79	91
Number of buses in fleet	87	68	62
Office space (sq ft)	2,500	2,500	2,500
Maintenance and repair (sq ft)			
Stalls	3,000	3,000	3,000
Tire and machine shop	750	750	750
Paint shop	1,000	1,000	1,000
Parts storage area	2,127	1,700	1,550
Total (sq ft)	6,925	6,450	6,300

Director and Staff

Personnel to operate the school bus system includes director and staff, bus drivers, and mechanics. The staff consists of a secretary, a clerk-typist, and the driver supervisors. All are assumed to be full-time employees. Staff size is assumed to be constant for the size range of bus fleets considered here. The staff composition for the first four years is shown as:

	Year			
	1	2	3	4 and on
Director	1	1	1	1
Secretary	1	1	1	1
Clerk-typist	0	0	1	1
Driver supervisors	1	1	2	3

Bus Drivers

The number of bus drivers required is determined from the fleet size and is estimated to be:

	Bus Size (Seats)		
	67	79	91
Number of buses	87	68	62
Number of drivers	96	75	68

Drivers are paid on the basis of actual hours worked, and the number of hours worked is shown in Table 5.

Mechanics

The shop staff is assumed to be composed of permanent employees and its size is as follows:

	Year 1			Year 2			Year 3			Year 4		
	Bus Size (Seats)			Bus Size (Seats)			Bus Size (Seats)			Bus Size (Seats)		
	67	79	91	67	79	91	67	79	91	67	79	91
Number of buses	13	10	9	22	18	16	56	46	44	87	68	62
Head bus mechanic	1	1	1	1	1	1	1	1	1	1	1	1
Senior bus mechanic	0	0	0	0	0	0	1	1	1	2	1	1
Bus mechanics	0	0	0	1	1	0	3	2	2	5	2	3

System Costs

On the basis of this system description, the costs of the various system elements can now be generated.

Bus Costs

	Expenditures for Buses (Thousands of Dollars)				
Bus Size (Seats)	Year 0	Year 1	Year 2	Year 3	Year 4
67	$157.3	$108.9	$411.4	$375.1	
79	250.0	200.0	700.0	550.0	
91	258.0	200.9	803.6	516.6	

Land Costs

All land is acquired in Year 0 as follows:

	Bus Size (Seats)		
	67	79	91
Acres	3.77	3.06	2.82
Cost @ $100,000/acre	$377,000	$306,000	$282,000
Paving @ $0.35/sq ft	48,720	38,080	36,720
Fencing* (dollars)	5,220	4,617	4,410
Total	$430,940	$348,697	$321,130

Buildings and Equipment

Costs of the buildings and equipment are incurred at the end of Year 0, so as to be ready for use during the first year of the C-5 base case.

The estimated costs of the buildings and equipment are shown below:

	Bus Size (Seats)		
	67	79	91
Office building @ $20/sq ft	$ 50,000	$ 50,000	$ 50,000
Maintenance facility @ $13/sq ft	90,025	83,850	72,150
Office equipment	2,000	2,000	2,000
Shop equipment	15,000	13,000	12,000
Total	$157,025	$148,850	$136,150

* Includes a 6-foot chain link fence to enclose parking area @ $3.50 lineal foot.

Director and Staff

The director's salary was set to be commensurate with the size of the bus fleet, as follows:

Bus Size (Seats)	Number of Buses in Fleet	Annual Salary
67	87	$15,000
79	68	14,000
91	62	13,500

Other salaries were derived from data presented in the chapter on cost elements. The salaries of the staff are shown below, including 10 percent for fringe benefits:

	Year			
	1	2	3	4
Director	$16,500	$16,500	$16,500	$16,500
Secretary	7,150	7,150	7,150	7,150
Clerk-typist	--	--	6,600	6,600
Driver supervisors	8,360	8,360	16,720	25,080

Bus Drivers

For this analysis, it was assumed that the bus drivers are paid on the basis of actual hours worked. A summary of driver hours and wages (including 15 percent fringe benefits) is shown below.

	Year			
	1	2	3	4
67-passenger buses				
Driver hours	7,209	12,834	33,873	54,290
Wages (dollars)	$29,197	$51,978	$137,185	$219,875
79-Passenger buses				
Driver hours	5,340	9,843	27,982	43,610
Wages (dollars)	$21,627	$39,864	$113,324	$176,621
91-Passenger buses				
Driver hours	4,895	9,149	27,341	40,762
Wages (dollars)	$19,825	$37,053	$110,731	$165,086

Mechanics

Annual wages for mechanics were taken to be as follows, including fringe benefits:

Head bus mechanic	$9,688
Senior bus mechanic	8,909
Bus mechanic	8,208

The total costs of mechanics are shown in the cost summary.

Fuel, Oil, and Parts Costs

Fuel, oil, and parts costs are directly proportionate to the number of miles driven. The costs for these items are shown in the tabulation as derived from the miles summary in Table 5 and the costs of 6.20¢/mile for 67-passenger buses, 9.19¢/mile for 79-passenger buses, and 9.65¢/mile for 91-passenger buses, as reported in the cost elements chapter.

Bus Size (Seats)	Expenditures for Fuel, Oil, and Parts (Thousands of Dollars)			
	Year 1	Year 2	Year 3	Year 4
67	$4.8	$ 8.9	$25.7	$38.2
79	3.7	9.6	32.0	45.2
91	3.7	10.1	32.4	44.2

Insurance

It is assumed that insurance costs must be paid in advance. The premiums therefore start at the end of Year 0, coincident with the bus purchases. The following tabulation shows the insurance costs.

Bus Size (Seats)	Insurance Costs (Thousands of Dollars)				
	Year 0	Year 1	Year 2	Year 3	Year 4 and on
67	$2.6	$4.4	$11.2	$17.4	$17.4
79	2.3	4.1	10.4	15.3	15.3
91	2.2	3.8	10.6	14.9	14.9

Cost Summaries

From the system description and cost analyses thereof given earlier, the cost summaries shown in Tables 8, 9, and 10 have been prepared, showing the costs for Years 0 through 3 and for Years 4 and all succeeding

Table 8

COST SUMMARY
FLEET OF 67-SEAT CONVENTIONAL SCHOOL BUSES
(Thousands of Dollars)

Item	Year 0	1	2	3	4
Capital costs					
Buses	$157.3	$108.9	$411.4	$375.1	$ --
Land, buildings, and equipment	588.2	--	--	--	--
Total capital	$745.5	$108.9	$411.4	$375.1	$
Operating costs					
Director and staff		32.1	32.1	47.1	55.4
Drivers		29.2	52.0	137.2	219.9
Mechanics		9.7	17.9	43.2	68.5
Fuel and parts		4.8	8.9	25.7	38.2
Insurance	2.6	4.4	11.2	17.4	17.4
Total operating	$ 2.6	$ 80.2	$122.1	$270.6	$399.4
Total cost for year	748.1	189.1	533.5	645.7	399.4

Table 9

COST SUMMARY
FLEET OF 79-SEAT TRANSIT SCHOOL BUSES
(Thousands of Dollars)

Item	Year 0	1	2	3	4
Capital costs					
Buses	$250.0	$200.0	$700.0	$550.0	$ --
Land, buildings, and equipment	497.6	--	--	--	--
Total capital	$747.6	$200.0	$700.0	$550.0	$
Operating costs					
Director and staff		31.0	31.0	45.5	54.3
Drivers		21.6	39.9	113.3	176.7
Mechanics		9.7	17.9	35.0	43.2
Fuel and parts		3.7	9.6	32.0	45.2
Insurance	2.3	4.1	10.4	15.3	15.3
Total operating	$ 2.3	$ 70.1	$108.8	$241.1	$334.7
Total cost for year	749.9	270.1	808.8	791.1	334.7

Table 10

COST SUMMARY
FLEET OF 91-SEAT TRANSIT SCHOOL BUSES
(Thousands of Dollars)

Item	Year 0	1	2	3	4
Capital costs					
Buses	$258.3	$200.9	$803.6	$516.6	$ --
Land, buildings, and equipment	457.3	--	--	--	--
Total capital	$715.6	$200.9	$803.6	$516.6	$
Operating costs					
Director and staff		30.5	30.5	45.5	53.8
Drivers		19.8	37.1	110.7	165.1
Mechanics		9.7	9.7	35.0	43.2
Fuel and parts		3.7	10.1	32.4	44.2
Insurance	2.2	3.8	10.6	14.9	14.9
Total operating	$ 2.2	$ 67.5	$ 98.6	$238.5	$321.2
Total cost for year	717.8	268.4	901.6	755.1	321.2

years. Summarized, the total capital costs and annual operating costs for the fourth and succeeding years are:

	Bus Size (Seats)		
	67	79	91
Capital cost (thousands of dollars)	$1,640.9	$2,199.9	$2,236.7
Annual operating costs (Year 4 and on)	399.4	334.7	321.2

Cost Comparisons

The preceding summary shows that the minimum investment to accomplish transportation for the C-5 base case alternative is $1,640,900. Because the life of a 67-passenger bus is only 15 years, as opposed to 20 years for the 79- and 91-passenger bus, and because the annual driver costs are lower for the larger buses (while the other operating costs are about the same), cost saving can be achieved by investing an additional sum in the larger buses. This additional sum earns an attractive rate of return, as the tabulation shows.

	Bus Size (Seats)		
	67	79	91
Total capital investment (thousands of dollars)	$1,640.9	$2,199.9	$2,236.7
Annual operating cost	399.4	334.7	321.2
Incremental investment over least-investment alternative	--	559.0	595.8
Annual savings resulting from additional investment	--	64.7	78.2
Approximate average annual rate of return on additional investment (percent)	--%	12.4%	13.8%

This comparison shows that the 91-passenger bus is superior, from an economic standpoint, for the flow patterns and route structure studied. If, on the other hand, fewer students were picked up from more originating

points, and if there were more routes with fewer miles, it is probable that the economics would favor a smaller bus. Other conditions may favor smaller buses, such as more flexibility to adapt to different route structures and less risk because of the small investment committed. On the other hand, if the drivers organize into a bargaining unit that successfully negotiates a minimum number of hours per day per driver, the economics of larger buses and fewer drivers will be even more favorable. The 14 percent rate of return gained by the additional investment is more than most taxpayers can earn on their funds, and the additional taxes needed in early years to finance the larger buses would amply repay the taxpayers in operating savings in later years.

The increased annual costs for the fourth and following years that would be caused by a minimum three-hour or eight-hour day at the rates assumed for this study are:

	Driver Cost Increase		
	Bus Size (Seats)		
	67	79	91
3-hour minimum (thousands of dollars)	$ 82.9	$ 5.0	$ 3.2
8-hour minimum	253.0	198.2	180.9

Cost Relationships and Extrapolations to Other Cases

Table 11 shows a comparison of some ratios for the proposed bus system of 91-passenger buses, compared with the average for all district-owned systems and contracted systems in California. Costs per bus and per bus mile are higher for the system described here because of the larger buses.

An analysis of the mileage variable and student variable costs associated with operating the system for the first few years shows the following approximate relationships between costs and numbers of students, which can be used to cost other transportation alternatives entailing similar patterns of pickup and delivery. The relationships are:

$$\text{Capital Costs (in thousands of dollars)} = 130 + 0.2236 \times \text{Number of Students}$$

$$\text{Annual Operating Costs (in thousands of dollars)} = 30 + 0.232 \times \text{Number of Students}$$

Table 11

STATEWIDE DISTRICT-OWNED AND CONTRACTED BUS SYSTEMS
1964-65

	No. of Buses Used	No. of Students Transported	Total Days Bus Operation	Total Miles Traveled	Total Operation Expense	Cost per Bus per Mile	Cost per Bus per Day	Annual Cost per Student
I District operating own system	6,664	668,886	1,080,273	67,473,492	$32,274,624.42	$.4783	$29.88	$48.25
II Districts contracting with private contractor	412	38,258	67,466	4,359,696	2,187,821.02	.5018	32.43	57.19
State totals*	7,076	707,140	1,147,739	71,833,188	$34,462,445.44	$.4797	$30.03	$48.73
III SFUSD district-owned system†	62	9,620	10,680	460,840	410,200	.8901	37.16	42.64

* Bus replacement expense is included in first column. Payments to common carriers are included as are all in lieu payments except those reported on separate individual reports.

† Includes average of 3 replacement buses/year.

Source of I and II: Bureau of School Apportionments & Report, Division of Public School Administration, California State Department of Education.

The letter that follows was received from the San Francisco Municipal Railway in answer to a request from the Institute for estimated costs of providing transportation for students as required in the C-5 base case Year 4 used in this study.

Public Utilities Commission
City and County of San Francisco

SAN FRANCISCO MUNICIPAL RAILWAY

949 PRESIDIO AVENUE
SAN FRANCISCO, CALIF. 94115

May 16, 1967

Subject:

Mr. Howard R. Ross
Transportation Analyst
Stanford Research Institute
Menlo Park, California 94025

Dear Mr. Ross:

The following estimate is based on the current agreement with the San Francisco Unified School District entered into on July 1, 1966, and the current availability of equipment. As these factors are subject to change the San Francisco Municipal Railway reserves the right to review and adjust this estimate if the plan is placed in effect.

ESTIMATED ANNUAL COST OF PLAN YEAR 4, C5 BASE CASE

STUDENTS TO BE TRANSPORTED -- 9620

EQUIPMENT:

45 Line Coaches @ 3 Hours Each	135 Hours
130 Extra Pull-Out Coaches @ 4 Hours Each	520 Hours
175 Total Coaches	655 Hours

COST:

655 Hours X $10.75 per hour - - - - - - $ 7,041.25 per day
$7,041.25 X 178 School Days - - - - - - $1,253,342.50 per year

In the estimation of the Railway Management and Staff the following factors should be considered in the analysis of cost.

(a) The total economic effect on the City in relation to "out of pocket" costs to the taxpayers.

(b) This estimate is based on 48 passenger coaches with 2 children only to a double seat. Using 3 children to a seat would reduce substantially the cost of operation.

(c) The number of available A.M. line coaches is reduced because of the early starting of Junior and Senior High Schools and the distance between schools.

Very truly yours,

W. R. Mason

W. R. MASON
Acting General Manager